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Effects of Vegetation Manipulation on Breeding Waterfowl in Prairie Wetlands —A Literature Review

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By Harold A. Kantrud

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By

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Abstract

Literature on the effects of fire and grazing on the wetlands used by breeding prairie waterfowl is reviewed. Both dabbling and diving ducks and their broods prefer wetlands with openings in the marsh canopy. Decreased use is commonly associated with decreased habitat heterogeneity caused by tall, robust hydrophytes such as *Typha* spp. and other species adapted to form monotypes in the absence of disturbance. Nearly all previous studies indicate that reductions in height and density of tall, emergent hydrophytes by fire and grazing (unless very intensive) generally benefit breeding waterfowl. Such benefits are an increase in pair density, probably related to increased interspersion of cover and open water which decreases visibility among conspecific pairs, and improvements in their invertebrate food resources that result from increased habitat heterogeneity. Research needs are great because of the drastic changes that have accrued to prairie wetlands through fire suppression, cultivation, and other factors. The physical and biological environments preferred by species of breeding waterfowl during their seasonal and daily activities should be ascertained from future studies in wetland complexes that exist in the highest state of natural preservation. Long-term burning and grazing experiments should follow on specific vegetatively-degraded wetlands judged to be potentially important breeding areas. Seasonality, frequency, and intensity of treatments should be varied and combined and, in addition to measuring the response of the biotic community, the changes in the physical and chemical environment of the wetlands should be monitored to increase our knowledge of causative factors and possible predictive values.

The natural forces of climate, grazing, and fire were once the major factors controlling the abundance and species composition of vegetation in prairie wetlands. Breeding and migrant birds that used the wetlands evolved successfully under these influences, as evidenced by numerous accounts of large numbers and varieties of water birds present under pristine conditions.

Although wetland drainage has received the most publicity, other activities of European man had greatly changed prairie wetlands by the end of the 19th century. Domestic animals confined within fences sometimes grazed wetlands almost year-round. Wetlands near farmsteads often became highly eutrophic from barnyard and feedlot runoff water. Prairie fires, feared by both farmers and cattlemen, were suppressed whenever possible, which allowed dead vegetation to accumulate in many wetlands. In agricultural areas, bottom soils of the shallowest, least permanent wetlands were regularly cultivated, even during wet years. In some years, wetlands with moderate water-retention ability could also be cultivated. During drought years, the bottom soils of more permanent water bodies were used to raise crops. The vegetation in all or part of some wetlands was mowed as often as possible for hay or bedding for livestock. Some wetlands were burned in the fall to reduce the amount of snow trapped in the basin or to discourage the spread of weeds; these wetlands could sometimes be cultivated the following spring.

In more recent times cultivation of steep slopes, use of row crops, and the practice of summer fallowing have caused much topsoil to move into the basins of countless prairie wetlands, further changing their

vegetative species composition and abundance. Dissolved salts and residues from agricultural chemicals probably have moved into many prairie wetlands. Irrigation practices have also altered the hydrology and vegetation of prairie wetlands. Finally, both herbage and woody vegetation have increased greatly in many wetlands in the eastern portion of the prairie pothole region. In this area, much livestock raising has been discontinued; thus, many formerly grazed or hayed wetlands that remain undrained now lie idle.

Although these land-use practices have undoubtedly affected the value of prairie wetlands to waterfowl and other birds, especially on privately owned lands, the effects have been only slightly less severe on many wetlands owned or managed by conservation agencies.

Research has emphasized bird habitat use, behavior, food habits, and recruitment of prairie-nesting waterfowl. Techniques used to manage upland nesting cover and, to a lesser degree, to control rates of hen and egg predation at upland sites are now fairly well developed. Yet little is known about practices that can rejuvenate vegetatively degraded prairie wetlands and restore their attractiveness to breeding waterfowl and other marsh and aquatic birds.

Wildlife problems associated with vegetation in wetlands and the response of wetland vegetation and animal populations to fire and grazing by domestic livestock are reviewed in this paper.

Weller (1978) stated that the theoretical basis for present marsh management techniques for wildlife is weak because of poor experimental design and inadequate evaluation of results; he encouraged the adoption of community-oriented management systems based on natural successional patterns that give benefits for a longer time and at lower cost than artificial systems. He identified burning and grazing as the systems most in need of study. Murkin (1979) also urged that the natural processes involved in the marsh cycle be studied; he stressed the importance of determining if semiopen marsh can be maintained in a productive state.

The natural fluctuation of water levels is probably the most important cause of vegetative change in prairie wetlands. Control of water levels has been extensively used to manipulate vegetation on many areas in the United States, but is not discussed here because such control is possible on only a small portion of the publicly owned wetlands in the prairie pothole region. Artificial management with costly herbicides, explosives, and sophisticated mechanical devices is also not considered here.

Problems

Physical characteristics of wetland vegetation to aquatic birds was first given specific attention by Beecher (1942), who also found a correlation between numbers of plant communities and bird nests found in an Illinois wetland. Still, little is known of the relations between physical and biological factors of wetlands and their effect on waterfowl (Poston 1969*a*). Perhaps the most widely recognized evidence of the sensitivity of marsh birds to changes in the structure and density of wetland vegetation is the generally decreased use by waterfowl of wetlands covered by dense stands of tall emergent vegetation and their increased use of the open areas, the shallow water sparsely vegetated with short emergents, and exposed shorelines and mud flats. This phenomenon was evident in early studies and observations of adult breeding waterfowl (Pirnie 1935; Ward 1942; Mendall 1948; Bue et al. 1952; Dzubin 1955; Evans and Black 1956), and in later investigations (Munro 1963; Larsson 1969; Hopper 1972; March et al. 1973; Björk 1976; Piest 1982). Preferences of dabbling ducks (Anatinae) for wetlands with openings in the marsh canopy or for flooded emergent vegetation of a shorter type are well documented (Marshall 1952; Glover 1956; Johnsgard 1956; Smith 1968; Drewien and Springer 1969; Poston 1969*b*; Hines 1975; Weller 1975*a*; McEnroe 1976; Bishop et al. 1979). Diving ducks (Aythyinae), of course, show strong relations with open water areas (Hochbaum 1944; Siegfried 1976; Stoudt 1982).

Detailed studies have related the daily activity patterns of breeding waterfowl to the increased attractiveness of wetlands that contain an interspersion of cover and open water. Such areas may provide better food resources according to Girard (1941), McDonald (1955), Sowls (1955), Williams and Imber (1970), Courcelles and Bedard (1978), Beule (1979), Kaminski and Prince (1981*b*), and Murkin et al. (1982). Multiple regression analyses indicate that an increase in the ratio of open water to emergent vegetation may manifest itself in dabbling duck populations through better isolation of conspecific pairs, and may provide a cue to quality feeding habitat (Kaminski and Prince 1984).

Nest densities or hatching success may also be greater in broken versus solid stands of emergent marsh vegetation (McDonald 1955; Steel et al. 1956; Nelson and Dietz 1966; Mihelsons 1968; Ward 1968; Krapu and Duebbert 1974; Mednis 1974; Murkin

1979). The importance of openings or bare areas along shorelines for preening, resting, or waiting sites for adult waterfowl is also evident (McDonald 1955; Smith 1955; Sowls 1955; Sugden and Benson 1970; Williams and Imber 1970; Seymour 1974; Fog 1976). Partial destruction of *Typha* spp. stands by herbicides has resulted in a 300–400% increase in adult ducks per unit of shoreline (Keith 1961).

Waterfowl broods also prefer semiopen or open emergent vegetative cover, as shown by early observations and investigations (Bennett 1938; Wellein 1942; Stoudt 1944; Evans et al. 1952; Beard 1953; Berg 1956; Evans and Black 1956; Johnsgard 1956), and later studies by Keith (1961), Trauger (1967), Williams and Imber (1970), Bengtson (1971), Stoudt (1971), Sugden (1973), Whitman (1974, 1976), Mundinger (1975), Newton and Campbell (1975), Patterson (1976), and Wheeler and March (1979).

In the single instance where more broods were observed in closed stands of vegetation, Ignatoski (1966) postulated that nest success might have been higher there or that predation might have been greater in the more open areas. Studies showing that broods of dabbling ducks prefer semiopen marsh include those of Chura (1961), Perret (1962), Parnell and Quay (1965), Quame and Grewe (1970), Thompson (1974), Hines (1975), Courcelles and Bedard (1978), Mack and Flake (1980), Godin and Joyner (1981), Ringelman and Longcore (1982), Sjöberg and Danell (1982), and Talent et al. (1982). Similar results have been reported for diving ducks (Hochbaum 1944; Hildén 1964; Lokemoen 1966; Hilliard 1974; Stoudt 1982). Use of wetlands by broods increased as the number of vegetative types at the edge of the open water zone increased (Hopper 1972).

Other relations between breeding waterfowl and the physical features of their wetland habitat have been proposed. Openings in shoreline emergent vegetation may make nest sites on nearby uplands more easily accessible to hens (Mednis 1974; Mihelsons et al. 1974). Some studies indicate that waterfowl may be less susceptible to predation in more open situations (Furniss 1938; Beard 1953; Trauger 1967; Moller 1975) or that predator pressure may be buffered from waterfowl by the presence of other forms of prey in more open areas (Weller 1979). It has also been noted that a heavy buildup of marsh vegetation can make nesting islands accessible to predators (Mihelsons 1968). Rogers (1964) postulated that predation on lesser scaup (*Aythya affinis*) nests may have increased in situations where females were forced to walk, rather than swim, to their nests.

Other marsh-dwelling birds and mammals may benefit greatly from the presence of openings in marsh vegetation (Beard 1953; Seabloom 1958; Weller and Spatcher 1965; Willson 1966; Orians 1972; Vogl 1973; Gorenzel et al. 1982; Nudds 1982; Stenzel 1982). Such conditions may also result in avian communities of greater species diversity or richness (Weller and Spatcher 1965; Weller and Fredrickson 1973; Weller 1975*a*, 1978; Harris et al. 1981).

Biologists have often attributed decreased wetland use by aquatic birds to decreased habitat heterogeneity caused by disruption (usually a reduction) of natural ecological processes, resulting in domination by tall, robust hydrophytes in such genera as *Scirpus, Carex, Typha, Salix*, and *Phragmites* (Fig. 1). In the absence of these processes, autogenic successional processes tend to build dense stands of such hydrophytes in most wetlands (Walker 1959; Jahn and Moyle 1964; Whitman 1976). Prairie wetlands are particularly susceptible to the establishment of monotypes because of low gradient shorelines, small differences in soils or organic matter content within basins, and the ability of many species to survive under a wide range of water conditions (Hammond 1961; Walker and Coupland 1968).

Typha spp. has spread rapidly across a major portion of the prairie pothole region. For example, Metcalf (1931) and F. M. Uhler (personal communication) saw few *Typha*-dominated wetlands in North Dakota during 1917–25. Metcalf found only common cattail (*T. latifolia*) in North Dakota, and the species was listed only for "springy places and in the vicinity of freshwater lakes." Since then, *T. angustifolia* and the extremely robust *T. "glauca"* (a presumed *T. latifolia* × *T. angustifolia* hybrid) have become dominant in thousands of prairie wetlands whose salinity ranges from fresh through slightly brackish (Stewart and Kantrud 1971).

Typha spp. is well-adapted to form monotypes (Linde et al. 1976). *Typha* seeds germinate under a wide range of water depths (Weller 1975*b*) and tolerate a wide range of soil types (Dean 1933). Older plants prevent competition from younger plants by autotoxicity (McNaughton 1968). Because shoot death in *Typha* spp. occurs late in the growing season, this plant's competitive advantage over other species is probably enhanced (Davis and van der Valk 1978). A process of self-thinning allows individual *Typha* plants to grow large; decomposition of these large plants may take as long as 2 years (Mason and Bryant 1975). Mechanical control of *Typha* spp. is difficult and expensive (Nelson and Dietz 1966; Weller 1975*b*).

When tall, robust emergents such as *Typha* spp. dominate a wetland, drastic environmental changes occur. Less insolation of marsh soils and the water column caused by tall emergents and their litter may reduce or eliminate other species of plants in the understory (Bennett 1938; Buttery and Lambert 1965; Spence and Chrystal 1970; Vogl 1973) or lower productivity (Willson 1966). Submerged plants, in particular, require water of sufficient depth to reproduce (Anderson 1978; Courcelles and Bedard 1978), and the buildup of litter and organic material from emergent species may reduce water depth or eliminate shallow water areas (Ward 1942; Walker 1959; Hammond 1961; Ward 1968; Beule 1979). Buildup of litter and the shading effect also may result in lower soil or water temperature and slower rates of plant decomposition (Willson 1966; Godshalk and Wetzel 1978). Various emergent species may decompose at different rates as the result of differences in species composition of macroinvertebrate populations (Danell and Sjöberg

Fig. 1. A prairie wetland unburned for more than 45 years; dense stands of ***Phragmites australis*** (foreground) and ***Typha angustifolia*** (background) lie offshore from the wet-meadow zone, which is dominated by a mature stand of ***Salix amygdaloides***. The area has seldom been grazed by livestock. (***Roberts Cty., South Dakota, 6 miles southwest of Rosholt; photo by H. A. Kantrud.***)

1979). Thus the development of monotypic stands of emergents may effectively remove some of the variation in decomposer organisms that could act to maintain or increase vegetative heterogeneity.

Management of Wetland Vegetation for Waterfowl

Burning

Komarek (1976) stated that the fire ecology of wetlands was sorely in need of scientific study. General references (Kozlowski and Ahlgren 1974; Wright and Bailey 1982) indicate that burning of marsh vegetation releases nutrients, opens the canopy and detrital layer, and allows for increased insolation and resultant earlier warming of bottom soils. Biological productivity usually increases following fire, even though plant species composition may be altered. Little change in species composition usually occurs when perennial species with meristem at or below ground level are burned during their dormant period.

Fires were common in prairie wetland vegetation in the early 19th century, as evidenced by the accounts of early traders and travelers. For example, in 1803 Henry and Thompson (1965) recorded fire rushing through "low places covered with reeds and rushes." In 1858 or 1859, Boller (1972) saw a large conflagration spread for many miles after being set by American Indians in "dry rushes in the prairie bottoms." Denig (1961), writing about his experiences during 1833–54, noted that fire would sweep over ice through wetland vegetation.

Impacts on Vegetation

Little is known about the environmental effects of fire in prairie wetlands. Much of the available information is obtained from general observations on wetlands where the fire frequency or season was unknown, or from fires set in a variety of vegetation types, usually on a nonexperimental basis. Hence, the results are often inconsistent and of minimal predictive value. Early studies by Lewis et al. (1928) indicated the changes in a few plant communities in central Alberta that could be expected in the presence or absence of a burning regime. Furniss (1938) noted that heavily lodged stands of *Typha latifolia* and *Scirpus validus* could be removed by fire in Saskatchewan wetlands. Ward (1942) found that dense beds of *Phragmites australis* in Manitoba wetlands could be opened up by either spring or late summer burns, but that only late summer burning killed the "roots" (root-crowns). Grange (1949) observed that smartweeds (*Polygonum* spp.) disappeared because of competition from *Carex* spp., *Typha* spp., *Phragmites australis*, and various grasses. He stated that burning was probably the only effective method of stimulating smartweed growth in Wisconsin wetlands. Truax and Gunther (1951) used fall and winter burns to control undesirable vegetation at Horicon Marsh, Wisconsin. Annual burning was used to maintain the *Carex* spp. community in other Wisconsin wetlands (Thompson 1959). Tester and Marshall (1962) saw little change in species composition of wetland vegetation when Minnesota marshes containing low fuel volumes were burned. Smeins (1965) listed a few wetland plants found in North Dakota marshes with a history of burning. Schlichtemeier (1967) successfully removed dead stems of *P. australis* and *Scirpus* spp. with a winter burn, even though snow covered the bases of the plants. Vogl (1967) found burning generally favorable as a means of controlling woody plant invaders in Wisconsin wetlands. Smith (1969) stated that *Typha* spp. could quickly be destroyed by fire in Alberta wetlands. Beule (1979) concluded that burning was an ineffective control for *Typha* spp. in Wisconsin wetlands unless the peat layer was also burned. Gorenzel et al. (1981) found that fire failed to kill *Typha* spp. and *S. americanus* in a Colorado wetland. Thompson (1982) studied the seasonal effects of burning *P. australis* stands in a Manitoba wetland, and concluded that the changes in species composition and productivity produced by fall burns were intermediate between those produced by spring or summer burns.

In seasonal prairie wetlands, Stewart and Kantrud (1972) thought *Polygonum coccineum* increased after burning. However, Millar (1973) found no change in stands of *Carex atherodes, Scolochloa festucacea*, and *Eleocharis palustris* after repeated burning, which indicates these common plants of seasonal wetlands are extremely fire tolerant.

The aforementioned studies and observations do not provide managers with definitive, quantifiable information needed to formulate burn prescriptions in prairie wetlands. Research on prescribed burning for these wetlands for wildlife production was urged by Ward (1968) and Weller (1978), but to date almost all marsh burning for improvement of Waterfowl habitat has been done on migration or wintering areas (Sanderson and Bellrose 1969; Rutkowsky 1978).

Effects on Breeding Waterfowl

There is little substantive information about fire as it affects use of prairie wetlands by breeding waterfowl. Bennett (1938) and Furniss (1938) probably were the first to postulate that some benefits to breeding waterfowl could accrue from marsh burning. Bennett recommended shoreline burning to open dense stands of emergents to increase foods for blue-winged teal (*Anas discors*), whereas Furniss noted that crow predation on Saskatchewan duck nests may be less in marshes where heavily lodged, old-growth *Typha* spp. and *Scirpus* spp. stands were opened up or rejuvenated by fire. Cartwright (1942) suggested that burning dense, matted vegetation in Manitoba meadows would improve use by nesting ducks. Ward (1942) stated that burned openings in dense stands of *Phragmites australis* were heavily used by breeding ducks at the Delta Marsh, Manitoba. Grange (1949) noted that plants that produced seeds readily eaten by ducks were easily lost to competition from other plants and considered burning the only effective way to control plant succession in Wisconsin wetlands. In South Dakota, Evans and Black (1956) noted that burning often improved use of wetlands by pairs of breeding waterfowl. Drewien and Springer (1969) observed that many burned wetlands lacked roosting cover in the spring, but that overall use of the wetlands by breeding pairs was not much affected.

Only a few experimental marsh burns have been conducted to study the effects on breeding waterfowl. Ducks showed increased use of winter-burned stands of *P. australis* and *Scirpus acutus* in wetlands in the Nebraska Sandhills (Schlichtemeier 1967). Ward (1968) found that in a Manitoba wetland fire opened up old stands of *P. australis* that formerly were almost devoid of duck nests and stimulated growth of *Scolochloa festucacea*, which supported highest duck nest densities. However, duck nest success was low the first year after a fire on low, *Poa pratensis* prairie in Iowa (Messinger 1974). A more detailed study was conducted by Björk (1976), who observed that in a Swedish wetland "severely damaged" by overgrowth of *Phragmites australis* and *Carex acuta*, burning and

Fig. 2. Prescribed spring burn being used to open a dense stand of *Phragmites australis* on the J. Clark Salyer National Wildlife Refuge. (*Bottineau Cty., North Dakota, 4.5 miles southeast of Westhope; photo by R. Giese.*)

mechanical methods of vegetation control resulted in much greater use of the area by breeding ducks, probably because of the presence of higher populations of chironomid insects. Prescribed burning of *P. australis* and *Typha* spp. during the dormant season is practiced on some National Wildlife Refuges (Fig. 2).

In the absence of water control, burning of vegetation in wetlands that naturally retain water only seasonally probably cannot be justified as a management practice for breeding waterfowl (Diiro 1982). Diiro found that increased early-season productivity of plants and invertebrates in basins burned the previous fall was offset by a general scarcity of water caused by the reduced snow-trapping ability of burned vegetation. In addition, snow accumulations tend to crush the softer vegetation found in seasonal wetlands, causing them to maintain an open or semiopen aspect during most springs. However, I believe that in pristine times vegetation in such wetlands would have burned more frequently than that found in more permanent wetlands. Long-term experiments on the effects of fire in the less permanent types of wetlands are needed.

Grazing

Much more is known about the effects of grazing than of burning on wetland plant communities. Unless unusually severe, grazing results in greater plant species diversity and the development of more intricate patterns and sharper boundaries among plant communities (Bakker and Ruyter 1981). Livestock trampling may affect the height and density of wetland vegetation more than consumption (Hilliard 1974). Overgrazing may cause a decrease in primary production (Reimold et al. 1975), an increase in water turbidity (Logan 1975), and areas devoid of vegetation (Bassett 1980), as shown in Fig. 3. Adaptations of wetland plants to grazing include nodal rooting and unpalatability (Walker 1968; Walker and Coupland 1968). Marshes often show greater vegetative response to grazing than upland communities (Bassett 1980). Lists of species that increase or are tolerant of grazing in wetlands in or near the prairie pothole region have been published by Evans et al. (1952), Smith (1953), Harris (1954), Smeins (1965), Dix and Smeins

Fig. 3. Long-term overgrazing can destroy nearly all emergent vegetation in those shallow prairie wetlands having firm bottom soils. (*Dickey Cty., North Dakota, 9 miles northwest of Forbes; photo by H. F. Duebbert.*)

(1967), Walker and Coupland (1968), Stewart and Kantrud (1972), and Millar (1973).

Effects on Breeding Waterfowl

Most active management of waterfowl habitat through grazing by domestic livestock occurs on the wintering grounds, where the usual goal is to increase the availability of seeds of annual food plants (Griffith 1948; Neely 1967; Ermacoff 1968; Sanderson and Bellrose 1969). The effects of grazing on the quality of wetland habitat used by breeding waterfowl have received much attention during general investigations but little by experimental design. Early work by Bennett (1937) and Furniss (1938) on wetlands in Iowa and Alberta, respectively, indicated that overgrazing degraded habitat for ducks that nested along marsh borders or over water, but that nest density increased and egg predation by crows was less when densely vegetated shorelines were opened up by livestock. Sowls (1951) noted that ungrazed edges of wetlands attracted few breeding ducks and stated that ducks might increase if such areas were moderately grazed. Disturbed shorelines that would otherwise have supported dense growths of *Typha* spp. and *Scirpus* spp. probably supported higher densities of dabbling ducks in South Dakota stock ponds (Bue et al. 1952). Glover (1956) concluded that light to moderate grazing of shorelines after 1 July would not harm their value to waterfowl. Studies of man-made wetlands confirmed the deleterious effects of overgrazing on use of these wetlands by breeding ducks (Shearer 1960; Uhlig 1963). A study conducted in South Dakota (Sand Lake National Wildlife Refuge, unpublished annual reports, 1957–61) reported increased use of grazed shorelines by breeding ducks, especially green-winged teal (*Anas crecca*), northern pintail (*A. acuta*), and blue-winged teal. Salyer (1962) found that grazing was less harmful to breeding ducks when water areas increased in number and depth. Light grazing was recommended by Munro (1963) to help open *Typha* stands, thereby improving prairie wetlands for breeding waterfowl. Poston (1969*b*) postulated that light to moderate grazing would result in near optimum conditions for northern shoveler (*Anas clypeata*) on Alberta wetlands. The moderately grazed portion of the wetland shown in Fig. 4 represents an interspersion of cover and open water that is attractive to waterfowl.

Drewien and Springer (1969) were probably the first to report that breeding ducks move to roost in more heavily vegetated wetlands at night. These wetlands contained patchy, moderately dense stands of *Carex* spp., *Polygonum coccineum, Scirpus* spp., *Scolochloa festucacea*, and *Typha* spp. The authors believed that lack of roosting cover did not limit densities of blue-winged teal on their South Dakota study area; sufficient roosting cover was always present because of other land-use practices, and even the overgrazed wetlands grew acceptable amounts of cover as the season progressed. During the day, the teal were found at higher densities on idle than on grazed wetlands; however, the authors inferred that this related to the proximity of upland nesting cover to the idle wetlands, rather than to differences among wetlands.

Kirsch (1969) found that pair use was lower on grazed North Dakota wetlands, but the differences between grazed versus idle wetlands were not significant. Cattle disturbance of duck nests was thought to be important during the study. Gjersing (1971) found high losses of duck nests due to livestock trampling around Montana reservoirs when the nests were within 7 yards of the shoreline. Winter grazing in Utah wetlands seemingly did not affect nesting dabbling ducks, but probably was harmful to divers (Hilliard 1974). In Denmark, Moller (1975) recommended grazing of wetlands during the nonbreeding season, and Fog (1976) believed that great portions of ungrazed marshes were lost to breeding ducks by the invasion of *Phragmites australis*. By using multiple regression analysis, McEnroe (1976) found that the percentage of shoreline grazed on natural wetlands was positively related to density indices (pairs per wetland) for the mallard (*Anas platyrhynchos*), gadwall (*A. strepera*), and blue-winged teal; however, intensity of grazing was negatively associated with densities of blue-winged teal and redhead (*Aythya americana*). A similar analysis of dabbling duck use of man-made wetlands in South Dakota showed species-specific preferences associated with differences in vegetation height, density, or diversity caused by grazing (Flake et al. 1977). The northern shoveler (*Anas clypeata*) made greatest use of pastured wetlands in England (Thomas 1980). The highest concentrations of breeding canvasback (*Aythya valisineria*) seen by Stoudt (1982) in a Manitoba study area were usually associated with pastured wetlands containing open or half-open surfaces and stands of *Scirpus acutus*.

Waterfowl Broods and Grazing

Relations between grazing and use of wetlands by waterfowl broods have also received some attention. Girard (1941) noted that broods would benefit if wetland shorelines in Montana were protected from

overgrazing. In Manitoba, the *Typha*-choked wetlands containing less than 10% open water received almost no use by duck broods (Evans et al. 1952). A history of light to moderate spring and fall grazing resulted in the open *Carex* spp. and *Scolochloa festucacea* habitat which was preferred by broods; ponds with broken stands of *Scirpus acutus* resulting from moderate to heavy grazing throughout the growing season were also extensively used. Broods were far more abundant on South Dakota livestock ponds with grassy shorelines than on those with mud shorelines created by overgrazing (Bue et al. 1952). Short emergent growth in sparse stands caused by grazing also provided the best brood habitat on eastern Montana stock ponds (Smith 1953). Harris (1954) observed that heavily grazed areas dominated by *Scirpus* spp. and *Juncus* spp. received the most use by broods in Washington potholes. Overgrazing, especially of small wetlands, created unsuitable brood habitat in South Dakota (Evans and Black 1956). Keith (1961) noted a large increase in brood density after partial destruction of *Typha* spp. stands by herbicides on Alberta impoundments, and he recommended combining grazing and herbicide applications to rejuvenate marsh

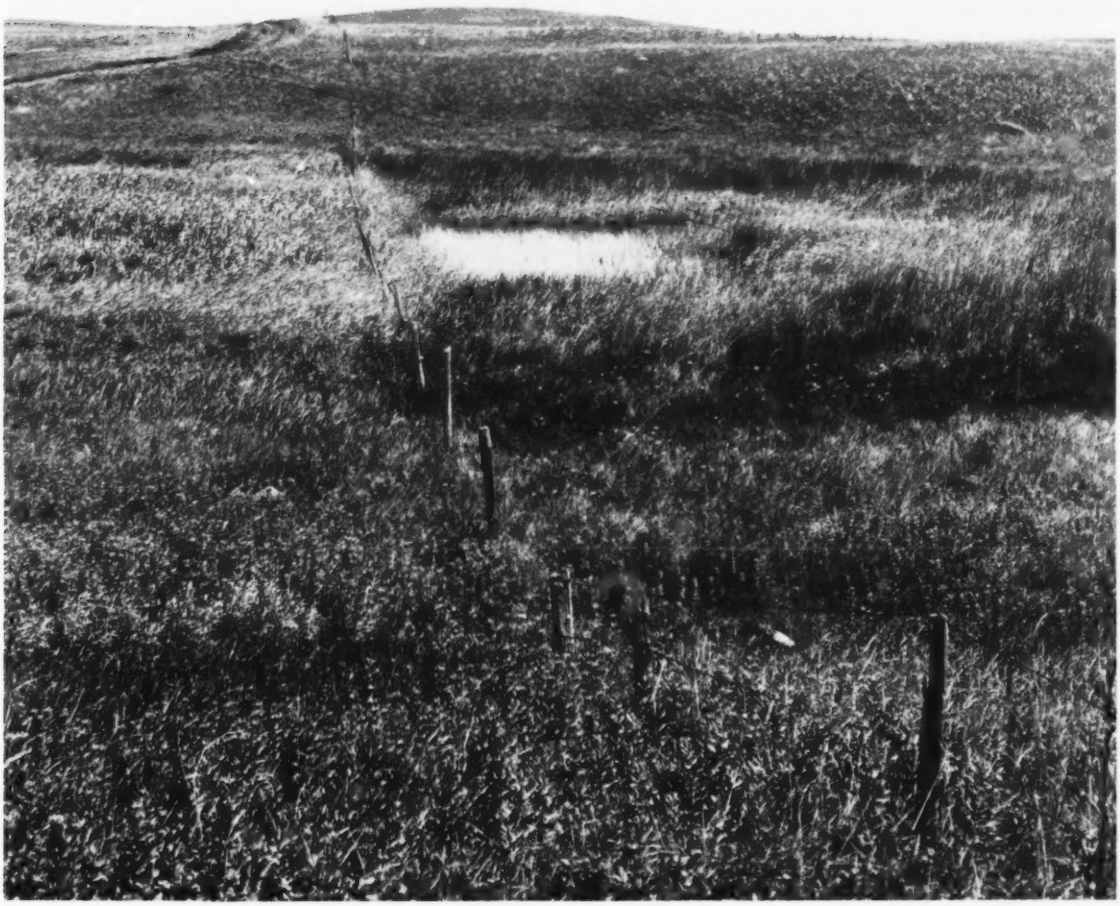

Fig. 4. Moderate cattle grazing created the semiopen and more diverse plant community shown on the right side of the fence; the portion on the left remains idle. (*Stutsman Cty., North Dakota, 2.5 miles east-southeast of Woodworth; photo by K. F. Higgins.*)

edges for ducks. In Colorado, broods used lightly to moderately grazed wetlands far more than either moderately to heavily grazed wetlands or those that lay idle (Hopper 1972). Evans and Kerbs (1977) identified South Dakota impoundments having gently sloping shorelines and light use by livestock as water areas that would develop the natural vegetation structure preferred by broods. Nonetheless, if such wetlands contain appreciable amounts of *Typha* spp., its influence on brood use may be negative (Mack and Flake 1980). Canvasback broods in Manitoba reached highest densities in pastured wetlands containing less than 33% emergent vegetation (Stoudt 1982). Hudson (1983) found that duck brood densities were positively related to the amount of vegetation in Montana livestock ponds, but no ponds totally covered with emergents were censused, and all ponds were grazed.

Invertebrate Food and Grazing

Only a few investigators have mentioned response by invertebrate animals to herbage removal by livestock. Munro (1963) stated that grazing of *Typha*-dominated prairie wetlands would increase the planktonic algae that are the primary foods of invertebrates. Hopper (1972) believed that light to moderate grazing of flooded emergent vegetation would provide invertebrate foods for duck broods and also allow them easier access to shoreline feeding areas. Some very large invertebrates in salt marshes (such as crabs) may decrease under heavy grazing, but recovery is probably very rapid once grazing pressure is lessened (Reimold et al. 1975). Decreases of invertebrate animals caused by grazing of wetlands probably occur only when livestock are present in enough numbers to destroy aquatic vegetation (Logan 1975).

Invertebrates have been known to be important in the nutrition of breeding ducks since the early 1960's (Voights 1973). Indeed, invertebrate numbers and taxa may surpass all other measured physical and biological variables as indicators of wetland quality for breeding ducks (Joyner 1980), although it may be necessary to determine the behavior and distribution of the invertebrates in order to accurately predict which microhabitats will attract feeding ducks (Joyner 1982). Management of invertebrates for waterfowl was reviewed by Schroeder (1973) who recommended manipulation of cover through water control, grazing, and burning. He cautioned that such manipulations should favor a good interspersion of cover types without creating excessive siltation, undue fluctuations of water levels during the nesting season, extensive reductions in plant abundance and diversity, and contamination of water supplies by toxic chemicals. When the invertebrate resources of prairie wetlands are manipulated by mechanical methods (Murkin 1979; Kaminski and Prince 1981*a*, 1981*b*), treatments are expensive and the response of breeding waterfowl is often small or of short duration.

Research Needs

The prairie wetland complex has been severely degraded. Thus, it is too late to determine precisely the natural plant associations and structural types of vegetation historically preferred by waterfowl species during different phases of the breeding cycle. Other than drainage, cultivation, and siltation, the worst problem now is decreased waterfowl use caused by the regression of many of the semipermanent wetlands toward *Typha* spp. monotypes, and the encroachment of woody plants such as *Salix* spp. The problem is especially noticeable in the eastern portion of the prairie pothole region where livestock production has decreased, and many wetlands now lie idle. The problem is no less severe on much of the publicly owned land devoted to waterfowl production. In this instance, wetland managers seldom have the time, equipment, or manpower to properly manipulate vegetation on wetlands. More important, managers lack the information needed to obtain desirable, predictable results. However, much useful information can still result by studying existing wetland complexes that are subjected to various land uses or combinations of uses.

Much remains to be learned about the physical and biological environments preferred by species of breeding waterfowl during their seasonal and daily activities. This should be ascertained from existing wetland complexes that are in the highest state of natural preservation. Knowledge of the preferred feeding, nesting, loafing and roosting areas, and reactions and adaptations of the birds to climatic changes and predator pressure would aid in evaluating future experiments in marsh management.

Armed with a better understanding of the life history of individual species, burning and grazing treatments should be applied individually and in combination to selected prairie wetlands of various classes, salinity subclasses, vegetative types, and sizes that are most important to the commonest species of waterfowl.

Burning and grazing experiments should stress seasonality, frequency, and intensity, and the interactions of these variables should be measured. Effects of cover level (amount of emergent cover) should be separated, if possible, from the effects of cover configuration (size of clumps, shape of clumps, distances betweeen clumps), as suggested by Murkin et al. (1982). The investigations should be long-term because of the drastic climatic fluctuations in the prairie pothole region. It would also be helpful if treated wetlands were dispersed over a broad geographical area to allow for differences in precipitation across the region. Studies should not be limited to the effects on waterfowl, but include the response of the vegetative community and the invertebrate food organisms of waterfowl. The response of other wetland vertebrates (primarily herbivores) to higher nutritive quality of burned wetland vegetation should also be measured as recommended by Smith et al. (1984).

Finally, changes to the physical and chemical environment should be monitored to increase our knowledge of causative factors involved in the biotic responses observed, and for the potential predictive values of abiotic factors in future marsh manipulations. Basic measurements should include winter snow accumualtions, fluctuations in water depth and temperature among wetland vegetation zones, insolation, and standard water quality parameters.

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Keywords: Waterfowl, wetlands, habitat, breeding, burning, grazing, foods, invertebrates, research.

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